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PART II.

WITH TWO MAPS.

EDITED BY

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I.

THE PALAEOZOIC FORMATION.

W. F. Cooper.

No subject open to our investigation is more interesting or economical than that department of inorganic geology embraced under its stratigraphical relations. The conditions attending the origin and deposition of the earth's crust are at the basis of our existence in a certain sense; that is leaving out the ethical element which it is hoped one may consider as the pre-existing state necessary for such physical operations as should best fit man for his abode throughout his entire cycle of life.

Whatever may be the relations sustained by our planet with the rest of the solar system, through the so-called nebular hypothesis; it is suggestive to follow out the comparisons of W. Prinz published in the *Annuaire de l' Observatoire Royal de Bruxelles* for 1891, in which the great continental torsions of the western coasts of America, Europe and Africa, western Siberia through the corresponding coast line of Australia, together with a fourth supposed by him to be indicated by the great chain of islands to which the Marshall group belongs; has been thought to be analagous with similar oblique lines observed on Mars, and less distinctly on Venus and Jupiter.

The similarities afforded by each of the three great continental systems is suggestive as bearing upon the similar primary condition attending their origin and fundamental development. We have counterparts in the respective irregular triangular outlines of North America, Europe, and Asia, in connection with the formation of South America, Africa, and Australia, all with a more or less triangular development, and with the apex of the triangle pointing southward. Similarly as the outlines become less triangular and larger from west to east, we have regularly separating bodies of water also increasing in size, and represented by the Gulf of Mexico, Mediterranean, and the Indian Ocean. The existence of greater depths in the western Atlantic and Pacific, in connection with corresponding altitudes on both of their immediate shore lines, may indicate a great law of stratigraphic equivalence or equilibrium, through which as we already

know, great accumulations result in areas of elevation, while vice-versa, lesser deposits might be held as forming the lowest depths. James D. Dana has attributed the zigzag arrangement of continents to torsion with the maximum torsion represented by a belt of volcanoes, and the earth's feature-lines as consequences in part of the pressure or tension attending torsion.

In our own country it can be readily shown that the North American continent had attained the outlines of its present form at the close of the Archaean age, subsequently developing southward into the Appalachian axis; that westward from there the surface deposits prove that it was coexistent with Carboniferous time, while west of a line drawn from the eastern longitude of Dakota the great Mesozoic and Tertiary deposits took place, the great climax of physical activity resulting in the evolution of the Mesozoic age, together with lesser resultant actions at the close of the Tertiary, or during a period very nearly contemporaneous with the Glacial epoch. Coexistent with this, it should also be observed that deposition took place from the north to the south, leaving the southern states adjacent to the Atlantic, Gulf of Mexico, and the Rio Grande of Tertiary and other later formations. We have attempted to show in a very general way the course of development among the sedimentary rocks, and it is thought, that as the general development has been westward, so we may be able to indicate the origin more exactly of portions of the Palaeozoic strata from sources eastward of their main deposition.

Any consideration of the origin of the later fragmentary rocks, involves not only an account of the adjacent land areas, but also the agencies by which they might be removed. The argument of Mr. Bull that the denuding action of tides must have been much greater among the rocks under discussion, cannot apparently find any very strong substantiation in nature, either from an organic or physical basis. Mr. Bull supposes that on account of the greater proximity of the moon at this time, that the action of tides would be greatly increased, causing material to be eroded and deposited in a manner almost inconceivable at the present. There are three objections to this theory: Primarily, that the nebular hypothesis of Laplace involves the fundamental idea that heat is evolved as a result of contraction, not taking into account that the intense heat of the sun would be more apt to cause an expansion instead of contraction along its diameter, according to all the known laws of Physics, while this involves indi-

rectly the relation of our satellite to the earth, and it to the sun. There is moreover, no physical action apparent, with the exception of some cases which will be observed, which would denote any violent physical force. Most of the strata of the Palaoezoic and Mesozoic were deposited during periods when life was very abundant, and its manner of preservation and more particularly of deposition show that the conditions were very quiet, and probably of long duration. In this connection it might also be well to remark that the very nearly equible temperature of the globe which allowed the same animals and plants to flourish on the equator and the Arctic zone at the same time, even as late as the Tertiary period, would also prevent the formation of oceanic currents on a magnitude equal to the present streams, but then as at present, winds acted in promoting such agencies. Another agent which has suggested itself is earthquake waves originating beneath the ocean. We know that the transporting power of water varies as the sixth power of the velocity, consequently if the velocity be increased ten times, the transporting power is increased 1,000,000 times. It has also been ascertained that water moving at the rate of three feet per second will carry angular stones the size of a hen's egg. What would be the result then of a wave 300 miles in diameter, and sixty feet high, moving at the rate of 370 miles per hour in its erosive action upon the adjacent coasts? One can readily conceive that it would be possible to carry boulders two feet in diameter a considerable distance, while the beds of conglomerates which exist in Scotland could be produced by this agency instead of the direct intervention of glacial action as Croll has supposed. We have good reason to believe that earthquake action was as frequent and extensive in the times under consideration as at present, and the great sea-wave just described, which took place during the South American earthquake in 1868, would probable be surpassed by those of previous epochs. Rivers also operated to a large extent, especially during the lower Carboniferous.

Among the elements necessary to the formation of sandstones, and as we shall also consider more particularly of conglomerates, are primarily the elevation of land areas above water as the Archaean rocks of Canada at the beginning of the Palaeozoic age, with other narrow ranges running southwestward parallel with the Atlantic, and still additional areas now represented by the Cordilleras. We have also to take into account that the amount of carbon dioxide in the atmos-

phere during early geological ages, exerted in connection with water a much more powerful and quickening effect in atmospheric and atmospheric-aqueous action, which must have greatly hastened the denuding action during Silurian, Devonian, and early Carboniferous ages, at the same time changing the chemical arrangement and physical form of the rocks. The lowest orders of plant and animal life also furnished contributions, which taken in connection with the large amount of organic material represented in some limestone formations, as for instance the Hudson group at Cincinnati Ohio, and the carbonaceous elements of many of the black shales constituting the Devonian and the relatively thin, but very important coal seams, clearly indicate the manifold operations of organic existence, as well as the inorganic. In addition to this, we have a counterpart to the formation of coral reefs at the present, duplicated to an unusual extent during the Niagara and lower Devonian, giving rise for example at Louisville, Ky., to a barrier which causes the falls of the Ohio.

An element involving both physical and organic connection is also paramount, as furnishing an index as to the position occupied by the Atlantic ocean. It seems quite apparent that since areas on both sides of its present basin have similarly equivalent, recurring faunas, often quite restricted as in the Cuboids zone, that it was influenced by physical environments which may have also operated in producing sediments for the adjacent coasts, but of this nothing can be said with certainty. Recent surveys have determined the position of three submerged mountain ranges running north and south in its central basin. It is certain that at least portions of the Mediterranean have been eroded to an enormous extent, producing material for the adjacent coasts. Before attempting to trace the origin of some of the sedimentary rocks subsequent to the Cambrian it will be necessary to determine the land areas existing in Ohio. That the Cincinnati geanticine existed at the close of the lower Silurian, forming an island in southwestern Ohio and the adjacent parts of Indiana and Kentucky, is indicated by the absence of upper Silurian and lower Devonian over that area, these formations being deposited on its margins northward. In Tennessee a hiatus is revealed on account of the Devonian black slate resting directly on Lower Silurian beds, clearly indicating the land ares during the upper Silurian and part of the Devonian. This land area had a great influence in building up the subsequent Palaeozoic rocks, as we shall see further on.

The fluctuations and arrangement accompaning the formation of the lower Helderberg strata in eastern New York, show that the upward movement begun there at the close of the Cambrian period, still further progressed after the deposition of the Hudson group, throwing the rocks of that formation above the level of the ocean into anticlinal and synclinal folds east of the Hudson, while decreasing in intensity westward. The Hudson formation may have furnished sediment from which the Oneida comglomerate was in part derived, but it is apparent that the later beds of the Niagara period had a connection with the vastly thicker formation in Canada through a channel possibly leading northeastward from western New York. With only a thickness of 300 to 400 feet in Ontario, increasing to 1,300 feet in Nova Scotia, it seems possible that the sediment was derived from regions north or northeast of New England, while the intimate relation of its fauna to that of England point to a very close biological relationship between the two areas, which oftentimes results from an uniformity of physical environments. The thinning out westward of the lower Helderberg group in New York, together with its comparative thinness in Tennessee, demonstrates it to be an essentially eastern formation. Unlike the Niagara, however, it thins out very rapidly to the westward until in Cayuga county it has almost entirely disappeared. It is obvious, however, to the most casual observer, that the Helderberg escarpment in Albany county must have had a much greater extension northward than at present, and after H. Fletcher's determination of the thickness in Nova Scotia (1,000 feet), we can probably admit the truth of Logan's determination that it was connected with the Canadian basin through the Champlain valley; bounded on the east and west by the folds of the Cambrian and the Adirondack range.

Continuing upward in the geological formations we find the Hamilton group with a thickness of 1,200 feet in the Catskill region, but rapidly thinning to the westward, until in western New York it is scarcely 200 feet thick, while at the falls of the Ohio the beds include 20 feet of impure limestone. In eastern Pennsylvania the greatest maximum thickness is 5000 feet, in the Gaspe region 6000 feet. The associations of the specimens I have seen from Perry (?) Maine would indicate an estuary connection with the Gaspe fauna, outside of the main line of deposition. The manner of preservation is very similar to specimens from western New York. It is impossible not to believe that the Hamilton strata did not extend farther eastward, northward,

and northwestward than at present, but all the strata have suffered denudation to an enormous extent, and we would not know of any northwestern connection, but for the Mackenzie river deposits. It is possible that portions of the Hamilton formation were derived from uplifted beds of the Hudson group and other formations east of the Hudson valley, and the Adirondacks may have contributed its share. It is obvious that the sediments could not have been derived from either the west or the southwest, and since according to Dana's determination the Champlain outlet was closed it is apparent from the relative thickness in the Catskill region, Pennsylvania and Nova Scotia, that the parent rocks may have been what is at present the bed of the western north Atlantic ocean, but it is entirely hypothetical. The lithological aspect of the formation is very suggestive as to its origin, especially when taken in connection with the organic remains. In eastern New York the strata are silicious with interspersed beds of shale, and containing land plants very similar to those described by Dawson from St. John. Lepidodendra as drift material, together with Psaronius actually growing and covered by the deposits. Farther westward the strata become thinner and more argillaceous, indicating quiet marine conditions, and greater distance from the source of the sediment. Certainly, however, there was an open connection with the eastern Canadian basin, by means of which an active inorganic and to a lesser extent faunal relation was sustained. It is also apparent that the strata in the Gaspe region were much nearer the original source of the sediment. I have rarely noticed very thin conglomerate beds in the Schoharie valley suggesting shore-line deposits—the precursors of greater strata which were deposited in the Chemung and Carboniferous strata.

Scarcely any subject in Palaeozoic stratigraphy with the exception of the Taconic question has caused more discussion than the relation of the Chemung, Catskill, and Waverly formations. Alexander Winchell would have had us believe that the Waverly and Catskill were in the same basin of deposition and coexistent. Another author contends, and very probably, that the Chemung and Catskill are equivalent formations with only a lithological difference due to different physical environments, while the Chenung and Portage are related but distinct formations. Prof. J. M. Clarke from palaeontological evidence links the Portage with the underlying beds. Prof. J. J. Stevensen on the other hand uses Chemung for a generic term with the divis-

ions Portage, Chemung and Catskill, and finds that the Catskill period presents a closely circumscribed area during the deposition of the last beds of the Chemung but was greatly enlarged to the southward during the formation of its upper beds. We incline to this opinion, at the same time correllating the Chemung of Brown county N. Y., with part of Mather's Catskill group of the Catskill mountains as Mr. N. H. Darton has done, leaving the Catskill group of Stevenson as a formation which had its greatest and typical development south of the Pennsylvania line, and outside of the typical locality which includes strata not understood when Mather made the survey of his district. It may be that the red Bedford shale lying at the base of the Waverly formation in Ohio represents a connection with the Catskill of the east about the latitude of Pittsburg, but it contains recurrent Hamilton species which lingered in the west long after the Hamilton formation was succeeded by later deposits in New York. The Bedford sea could probably be represented as an estuary in Ohio, which was bounded on the west by the fold of Cincinnati rocks and those of later age. The gradual uplifting of northern Ohio which had then begun, continued in operation until the following lower Carboniferous horizons were deposited on a shoreline which steadily progressed southward.

The Chemung group is 350 feet thick in southwesthern Virginia on the Tennessee line, but rapidly thickens northward, being 3800 feet thick on the boundary line between Virginia and Pennsylvania, 4700 feet in Huntington county Pennsylvania, and four thousand feet near the New York line on the Delaware river, while in the Catskill mountains it is 3000 feet thick. In southwestern New York the Chemung is 1200 feet thick. The Chemung strata thin out to the westward and south-westward in Pennsylvania, but northward along the western boundary line it reaches a thickness of 1400 feet in Crawford county near Lake Erie. The Erie shales which represent the western extension of the Chemung in Ohio rapidly thin out as we approach Columbus, almost, if not quite disappearing as we approach that city. Prof. E. Orton states its thickness at 300 feet, but it is very variable. When the stratigraphy is subject to so much variation in thickness, lithological appearance, and distribution, we must be prepared to be somewhat at variance concerning the origin of its individual beds of conglomerates, as well as the remaining strata. Prof. I. C. White has correllated the Panama with the Alegrippus conglomerate,

and likewise the Salamanca layer with the Lackawaxan pudding-stone, thus making the two layers continuous over southwestern New York, across eastern Pennsylvania on a line rudely parallel with the Blue ridge into southwestern Virginia. In the Catskill mountains a layer of conglomerate is present which may be equivalent to one of these layers. It seems quite natural that the conditions attending the formation of the Hamilton group again operated to a lesser extent during the upbuilding of the Neodevonian. It cannot be denied that the lower Chemung was restricted in its basin to the northward, while in its limited extension east of the Hudson the highlands of New England may have furnished material for its upbuilding. In Ohio rather abruptly limited on the west by the Cincinnati uplift, the strata were deposited in a sea whose main axis ran north and south, and which received its sediment from currents directed northward. It may possibly be that the hiatus existing in Virginia between the Archaean and Tertiary went to supply part of this material, while it is natural to conceive that strata now only represented by the West Indies may have not only sent its contribution to this formation but still others in the geological scale. But of that nothing can be said with certainty. The effect of tidal currents is essential in producing such beds of conglomerates as have been laid down during this age, and in the flat and round pebbles of the Panama and Salamanca conglomerates, we have illustrated the active erosive in shallow waters, with the result of somewhat different physical environments.

Although somewhat intimately related in the eastern extension of its basin with its underlying rocks the deposition of the Waverly shales in Ohio witnessed an important change in the physical geography of the lower Carboniferous formation. On the northwest there was a close connection with the Marshall group in Michigan, and even after the Berea and Cuyahoga shales had been uplifted in northeastern Ohio the channel remained open at least until the middle Waverly freestones had begun to be deposited farther south, probably receiving accessions for growth from the Cincinnati geanticline, but the physical conditions for faunal existence farther south toward the Ohio river were not favorable at the close of the lower first division of the Waverly. East and northeast from central Ohio, the conditions attending the deposition of the middle and upper Waverly were apparently more favorable under the coal bearing formations

south of lake Erie, and it is only in that way that we can account for the occurrence of conglomeritic beds and other higher horizons, which are not represented in northern Ohio, but which nevertheless reappear in Pennsylvania. To Prof. C. L. Herrick we are greatly indebted for the determination of the different zones of the Waverly, and more particularly of their faunal characteristics. The student desiring to obtain some conception of the evolution of biological forms from the Devonian to the Carboniferous, together with an exact idea of the stratigraphic relations in this formation, is referred to the Bulletins of the Scientific Laboratories of Denison University volumes III-V, and volume VII of the Ohio State Geol. Survey. While the increasing thickness of the upper Waverly formation toward southern Ohio points in that direction as from which sediments were borne, we are apparently confronted with the fact that the rivers which deposited the conglomerates came from the northeast. They differ from the beds forming the Chemung conglomerates in the comparative restriction of their areas and manner of deposition, but are so closely allied lithologically as to point towards a common source of origin. In the Waverly all that we know definitely of the upper conglomerate which may represent a repetition of the lower member is that it was deposited in the deepening sea near Portsmouth, Ohio, and along a north and south line east of Newark, through Mount Vernon, near Independence which is about twelve miles southeast of Mansfield, where it was at one time confused with the Carboniferous conglomerate 150 feet higher, and having on both its east and west sides broad and gradually decreasing deposits. A section at a right angle to this line of deposits at Lyon's falls near Independence shows a layer forty feet thick thinning out very rapidly east and west. At the "Back bone" one mile east it is only two feet thick, while it entirely thins out westward. It disappears under the coal measures northeast of Wooster, and we are left to speculate as to its further course, and origin. It may be that some of the sub Olean conglomerates in northwestern Pennsylvania belong to the same horizons, but this remains to be verified.

The beds of sandstone overlying conglomerate II near Black Hand occasionally contain pieces of chert, which is characteristic of the St. Louis formation at New Providence Indiana. It is very suggestive as showing the direction taken by some of the currents which deposited the upper Waverly, besides furnishing an index as to the age

of those sandstone beds underlying the Chester or Maxville limestone.

The great salient features concerned in the growth of the American continent are represented by the Archean nucleus with its essential importance in building up strata and protecting the life of the seas washing its shores ; the Cincinnati geanticline further modifying and hastening the processes long since inaugurated, and forming a basin which exerted a profound influence not only physically but biologically; and finally the Appalachian revolution which terminated to a great extent courses which had long been in operation for the preparation of the world for the coming of man, but which, nevertheless, made tangible the physical environments necessary for the higher existence.

II.

LICHENS OF LICKING COUNTY, OHIO.

J. ORRIN R. FISHER, M.S.

The following list is intended to include such lichens as have been found in this county, and worked up by the author during the school year of 1893-94 in the Denison University laboratories. To this list have been added a few specimens from the neighboring county of Muskingum; the localities given being followed by "L." for the former, and by "M." for the latter county.

The names and authorities are given in conformity with Tuckerman's "Synopsis of the North American Lichens," and most of the identifications have been confirmed by other investigators.

In this list are at least four specimens not before reported for the State, viz:

Cladonia symphycarpa Fr.;

Lecanora cenisia Ach.;

Pannaria nigra (Huds.) Nyl.;

Peltigera canina (L.) Hoffm., var. spongiosa Tuckerm.

As to collecting it is difficult to say where are the best localities, for all are good; but a trip to Black Hand for crustaceous and rock lichens, to Buckeye Lake or Munson's Hill for fruticulose lichens, and to the region around Newark or to Pleasant Valley for foliaceous ones, will reward the collector with many fine specimens.

The study of lichens is an interesting one, and offers to the diligent and careful student a rare field for investigation from the fact that there are many points yet to be determined in their structure, and very many specimens yet to be classified and named.

The following lines quoted by Henry Willey in his "Introduction to the Study of Lichens," represents the attractiveness of the study:

"If I could put my woods in song,
And tell what's there enjoyed,
All men would to my garden throng,
And leave the cities void.

In my plot no tulips blow;
Snow-loving pines and oaks instead;
And rank the savage maples grow,
From Spring's first flush to Autumn red.
My Garden is a forest ledge,
Which older forests bound."

* * * * * * *

"Wings of what wind the Lichen bore,
Wafting the puny seeds of power,
Which, lodged in rock, the rock abrade?"

LICHENES.

Tribe I. PARMELIACEI.

Ramalina, Ach., DeNot.

R. calicaris, (L.) Fr., var. fastigiata, Fr. Granville, L., and Adamsville, M. Occurs on trees, &c., in moist localities.

Usnea, (Dill.) Ach.

U. barbata (L.) Fr., var. florida Fr. Buckeye Lake, L., Adamsville, M. On trees and dead wood, abundant.

Theloschistes, Norm. Emend.

T. concolor (Dicks) Tuckerm. Granville, L. Common on trees and rocks.

Parmelia, Ach., DeNot.

P. borreri Turn., var. rudecta Tuckerm. Granville, Buckeye Lake, L.

P. cetata Ach. N. E. of Granville, L.

Physcia (DC., Fr.) Th. Fr.

P. speciosa (Wulf., Ach.) Nyl. Fair grounds, Newark, L. On trees.

P. hypoleuca (Muhl.) Tuckerm. Spring Valley, Granville, L.

P. leucomela (L.) Michx. Buckeye Lake, L.

P. aquila (Ach.) Nyl., var. detonsa Tuckerm. Toboso, or Black Hand, L.

P. stellaris (L.) Tuckerm. Granville, L.

P. tribacia (Ach.) Tuck. herb. On Newark Fair Ground, and near Haven's Quarry, S. of Newark, L.

P. HISPIDA (Schreb., Fr.) Tuck. herb. On branches in N. side of Cranberry Marsh, Buckeye Lake, L.

STICTA (Schreb.) Fr.

S. AMPLISSIMA (Scop.) Mass. Granville, L, Abundant.

S. PULMONARIA (L.) Ach. Common in Licking county, but none found with apothecia. A specimen collected in a strip of dry woods one mile N. of Sonora, Muskingum county, exhibited apothecia containing the typical cymbiform spores.

PELTIGERA (Willd, Hoffm.) Fée.

P. HORIZONTALIS (L.) Hoffm. Munson's Hill near Granville, L., on the earth; near Adamsville, M., on mossy rock.

P. RUFESCENS (Neck.) Hoffm. Toboso, L. Under a rock ledge.

P. CANINA (L.) Hoffm., var., SPONGIOSA. Tuckerm. Granville, L.; Pleasant Valley, M. On the earth and dead-wood.

PANNARIA, Delis.

P. NIGRA (Huds.) Nyl. Toboso, L.; Pleasant Valley, M. On large sandstone rock.

PLACODIUM (DC.) Naeg. & Hepp.

P. FERRUGINEUM (Huds.) Hepp. Very abundant on small stones in the vicinity of Granville, L.

P. FERRUGINEUM (Huds.) Hepp., var. DISCOLOR Willey in Litt. Granville, L.

LECANORA Ach., Tuckerm.

L. CENISIA Ach. Granville, L.

L. SUBFUSCA (L.) Ach. Granville, L. on wood and rocks.

L. VARIA (Ehrh.) Nyl. Granville, Buckeye Lake, L.; Pleasant Valley, M. On trees, well distributed in both counties.

RINODINA Mass., Stizenb., Tuckerm.

R. SOPHODES (Ach.) Nyl, var. EXIGUA Fr. Pleasant Valley, M., on bark of trees.

TRIBE II. LECIDEACEI.

CLADONIA Hoffm.

C. SYMPHYCARPA Fr. Granville, L., Zanesville, M., on the earth abundant.

C. MITRULA Tuckerm. Granville, L.

C. PYXIDATA (L.) Fr. Granville, L.

C. FIMBRIATA (L.) Fr. Granville, L.

C. GRACILIS (L.) Nyl., var. VERTICILLATA Fr. Munson's Hill near Granville, L.

C. SQUAMOSA Hoffm. Granville, L.

C. DELICATA (Ehrh.) Fl. Granville, L., Zanesville, M.

C. FURCATA (Huds.) Hepp., var. CRISPATA Fl. Granville, L.

C. RANGIFERINA (L.) Hoffm. Toboso, L., on the earth upon Black Hand Rock.

C. RANGIFERINA (L.) Hoffm., var. ALPESTRIS L. Locality same as preceding.

C. CRISTATELLA Tuckerm. Granville, L.

C. UNCIALIS (L.) Fr. Toboso, L. on Black Hand rock.

C. CÆSPITICIA (Pers.) Fl. Nashport, M.

C. RAVENELII Tuck. "Alligator Hill" near Granville, L. on board fence.

BEOMYCES Pers., DC.

B. ROSEUS Pers. Toboso, L. on the earth upon Black Hand rock. Rare, having been found in no other locality.

LECIDEA (Ach.) Fr. Tuckerm.

L. ALBOCÆRULESCENS (Wulf.) Schaer. Toboso, L.

L. PLATYCARPA Ach. Toboso, L.

BUELLIA DeNot., Tuckerm.

B. PARASEMA (Ach.) Th. F. Pleasant Valley, M. on trees.

B. PETRÆA (Flot., Koerb.) Tuckerm. Granville, L.

TRIBE III. GRAPHIDACEI.

GRAPHIS Ach., Nyl.

G. SCRIPTA (L.) Ach. Granville, L. abundant on dead wood.

TRIBE V. VERRUCARIACEI.

VERRUCARIA (Pers.) Tuck.

V. RUPESTRIS Schrad. Fultonham, M.

PYRENULA Ach.

P. NITIDA Ach. Granville, L.

III.

A CONTRIBUTION TO THE KNOWLEDGE OF THE PRE-GLACIAL DRAINAGE OF OHIO.

PART II.

Pre-Glacial and Recent Drainage Channels in Ross County, Ohio.

By Gerard Fowke.

Ross county presents an interesting field for the student of glacial geology.

The southern limit of the ice-sheet is marked by a well-defined terminal moraine which follows almost exactly the diagonal of the county, as it enters at the northeast corner near Adelphi and passes out about two miles beyond Bainbridge at the junction of Ross, Pike, and Highland counties. There are few points along this line where the drift is not a prominent feature of the landscape; in many places it has a thickness of more than 100 feet exposed and occasionally attains an elevation of about 150 feet above the streams which flow across it or along its margin. Some very large "kettle-holes" exist on this border; while numerous sections along the nearly vertical banks of streams or in excavations for ballast or pike material afford excellent opportunities for observing the complicated structure produced both by the ice itself and by currents from its melting. These features, however, except perhaps as to the thickness of the deposits, are common in all glaciated regions and may be as well studied elsewhere; but there are few, if any, places where in an equal area may be found so great an alteration in water courses as has taken place in the southwestern quarter of this county since it was first invaded by the glacier.

By reference to the map (Plate I), it will be seen that, at present, Paint creek forms the western boundary of the county from Greenfield to the mouth of Rocky Fork, near the point marked *H*. Thence it flows nearly east for about three miles, after which its general direction is northeast to the point *E*. Here it bends abruptly to

the southeast, then toward the northeast to the point *C*, from which its general course is east to the Scioto river. Somewhat more than two miles above Rocky Fork, a considerable tributary, Rattlesnake Creek, or Rattlesnake Fork, enters ; and the enlarged stream pursues a tortuous course of several miles to *H*. At the point *G* is a ledge of limestone, forming the Falls of Paint Creek. The largest tributary within Ross county is North Fork whose head-springs are on or beyond the Fayette county line; it flows southeast past Frankfort and enters the main stream at *C*. There are many smaller streams, and scores of ravines, some of them several miles in length; but only those are represented which contain water all the year. The lowest level at which the bed-rock is visible, whether in the bed of streams or on its line of contact with the drift, is shown by heavy dotted lines; no account is taken of the superficial deposit on the table lands, which in most places is quite thin and frequently is altogether lacking. In the low-lands the drift extends to a greater depth than has ever been reached by well diggers. The crossed lines denote drift-filled valleys in which there is now no running water in greater amount than may come from a small spring.

A tour of discovery by a person unfamiliar with the country, starting at Greenfield to follow the course of Paint Creek, would, to judge from the experience of the writer, result somewhat in this way, except that a large part of the territory here figured would have to be closely and accurately examined many times before the facts were understood:

From Greenfield southward the investigator will find limestone cliffs bordering the stream, separating here and there with little level valleys between them, the water skirting the rock along first one side and then the other. Tributary ravines, dry most of the year, show similar gorges or canons. When he reaches Rattlesnake he finds the valley swing east and widen considerably, with heavier deposits of drift; but suddenly it turns southward again through a valley more contracted, with rocky walls. Following these, he presently turns northward, and finds drift deposits on both sides of him. These, however, soon disappear, and he follows a long loop through bed-rock, coming after awhile to a place where the stream again flows through drift almost to the mouth of Rocky Fork. From here, for several hundred yards (at *H*) the bottom of the creek is solid rock, with thousands of "pot-holes" and long narrow grooves cut by the stones

and sand whirled along by the rushing water which in the last 200 yards of this rocky bed has a fall of 19 feet. Suddenly the turbulent stream comes to rest in a quiet pool which has a depth near its upper edge of about 80 feet. The right bank continues its course as an unbroken bluff; but the left bank abruptly terminates with a sharp anvil-like point projecting into the deep water. On crossing over, it is seen that the upper edge of the pool, on the northern side, is some distance above this point, with a muddy shore in which no limestone is apparent. This shore gradually curves around toward the east until it forms a bank to the creek parallel to that on the south side. Climbing the gravel hills to a point north of *H*, the traveler sees to the westward conical and roof-like hills, whose smooth-flowing outlines show them to be of drift material, stretching away to the bend just below Rattlesnake which he had left some hours before; and he further sees that they appear to cross at the points where he had lost the limestone on his way down. Thorough examination, involving many miles of tramping to and fro, convinces him that Rattlesnake is flowing in a pre-glacial valley which was filled with drift from the junction of Paint creek to this deep pool at Rapids Forge *H*; and that after seeking outlets in various directions as shown by abandoned channels and minor terraces it finally escaped along its present crooked way, regaining its former bed by cutting out the limestone which had made its southern boundary, washing down-stream the gravel that it found filling the present pool and making with it a dam which retains the water. He finds also, that the beds of both Rocky Fork and that portion of Paint creek above the mouth of Rattlesnake have been eroded in post-glacial times.

Somewhat more than a mile below the pool at Rapids Forge, the rugged hills on the south cease and in their stead appear conical knolls which cause the observer to rub his eyes and wonder if he has been suddenly transported to the region of Omaha; for at no nearer point will he find such remarkable resemblance to the Missouri river bluffs. Next, he sees a valley opening from the south, and then reappear the hills capped with Waverly sandstone such as he had seen above; but they are farther away from him. Following the road along the creek bank he soon approaches their foot; and now the hills on the north side have receded, while the creek, making a salient angle, seems bent on following them. Leaving the road, which continues in nearly a straight course and following the creek to the Falls *G*, he finds a

cataract 8 feet high pouring over the last exposure of limestone in the valley, the bed rock from here to the Scioto being shale. In the bottom land, just east of the falls, is a very large gravel deposit, part of the old moraine, with lower ground between it and the hills to the southward. It is apparent that at a comparatively recent date the creek has flowed through, or south of, the site of Bainbridge. More time is required for one fully to realize that he has followed thus far what was once only a tributary to a far larger stream; that Rattlesnake formerly had its mouth just above the Falls; and that only now has he reached the true valley of Paint creek. But the sudden widening from a few hundred feet to nearly a mile; the break in the hills to the southward, filled with gravel-knolls over 150 feet high; the persistence of this gravel up to Beech Flats with rock-capped hills on either side; the width of the valley, almost as great at the Falls as at any point below;—all are proof that the headwaters of Paint must be sought to the southwest, possibly as far away as Brown or even Clermont county, for all the streams rising in the area which may formerly have been drained by this lost part of Paint creek flow southward or westward through gorges or narrow troughs in their whole course, none having the broad valley so characteristic of this. Mr. H. W. Overman, of Waverly, pointed out years ago that the drainage of Ohio Brush creek was reversed, its natural course being to the north instead of to the south. The same will probably be found true of other streams still more to the west.

Leaving this for future determination, our student goes on down the broadened valley, admiring the wonderful fertility of the soil, the fine farms, the picturesque beauty of the sloping or, sometimes, precipitous hills that border it. Perhaps he turns aside at *F* to examine the vertical exposure of nearly 300 feet of shale at Copperas mountain into whose base the creek has cut its way; he notices a dark line near the top which marks the separation between the Devonian and the Subcarboniferous. Similar, but much smaller, sections may be found at other places where the creek cuts against one hill or the other as it swings back and forth across the intervening space. Not far below *F* is a fine vertical exposure of gravel capped with clay and sand, in all about 60 feet; the bank is rapidly caving and is now several yards within the original line of the pike which has been twice moved back. Finally the creek, skirting along the southern range of hills, is lost to sight for about three miles and is next seen at Slate

Mills. But instead of flowing on gravel as heretofore, it is on a bottom, and between banks, of bedded shale, with gravel on the farther side above the shale. While the traveler is pondering over this, he suddenly observes that it is flowing to the right, as it did when he crossed it before, two miles below Bainbridge; and he knows he has not crossed it twice. He looks on, in the direction toward which he is traveling, and sees the same range of hills on either side bordering a drift-filled valley such as he has been coming along for several miles; but he is now looking *up* the stream instead of *down* it. More puzzled than ever he leaves the pike and follows the stream which soon curves around to the westward. He thinks this is as it should be until he unexpectedly finds himself on a railway which he does not remember to have seen; true there was a railway near Bainbridge, but he knows he is not back there; besides it is not going in the same direction. Presently he sees another railway; both of them, with the creek, disappear in a narrow gorge which he certainly has not seen before. Next, he notices that the stream is not more than one-fourth as large as it should be. Wondering if he is bewitched, he climbs a hill, looks to the westward, recognizes numerous places he has passed; looks eastward and sees the continuation of the valley, but without a sign of water in it. He tries to trace the stream he has just left; it passes the bridge where he first saw it, wanders through a narrow valley, runs up to a high hill, and apparently stops there. He then walks south across fields, thinking thus to reach the larger stream, and finds himself at the bridge again. He inquires at the mill near by as to the location of Paint creek, and is told with a vague general flourish of the hand in the direction of the setting sun, that it is "up that way." Retracing his steps for weary miles, he finds his lost stream half-way back to Bourneville. Determined not to lose it again, he notes the trend of the current, starts in the same direction closely watching the hills to the south, and is satisfied there is no place it can pass through. He can not *see* the stream, but he knows it runs along the foot of the hill under those huge elms and sycamores. Soon he finds himself at the foot of the hill near D; but there is no creek visible—the gravel is piled up against the slope. Uncertain whether to swear or to pray, he walks on and reaches the mill, whose owner eyes him suspiciously. Making further inquiries, he learns that the bridge is over North Fork, which flows into Paint creek about two miles from where he stands. Taking the new direction to the

southward, he finds Paint creek again at *C*, and follows it thence through a broad valley to the Scioto bottoms. Coming back to *C* and ascending Paint creek he observes that the hills on either side contract in a V shape toward the mouth of Ralston's run, which runs through a level bottom about 500 feet wide with steep hills on either side. From here up to a ravine putting in from the west, there is a strip of bottom land on one side of Paint creek, nowhere wider than 400 feet; and from this ravine up to the point *E* the hills ascend from the edge of the water which flows on solid rock all the way. At *E* he finds the creek in its proper channel at the foot of the hill, under the elms and sycamores, just as he had thought when looking from the pike.

The order of events that gave rise to these conditions is apparently about as follows:

It is plain that the glacier reached, as a mass, to the old valley of Paint creek and that it did not ascend the hills on the southern slope or even reach to them anywhere below the point *F*, except at the points *B* and *D*. About two miles below Bainbridge, the drift is piled half-way to the tops of the hills to the south, and the valley along here must, for a time, have been entirely closed by ice. There is no doubt that it thus followed the valley nearly or quite to its head, leaving the deposits above Bainbridge, probably forming the Beech Flats, and filling up all the valleys when it passed out upon the limestone table-land beyond the rugged hills of shale and sandstone; thus deflecting toward the Ohio all the waters which in this region had flowed into Paint creek. But, as above stated, this is still to be worked out. At the point *B* where the creek formerly discharged into the Scioto the drift is fully 100 feet higher than the highest river terrace; the distance between the hills, measured on the drift, is a little less than one mile. The flat-topped hills at this place are about 100 feet higher than the drift. This denotes a sufficient thickness of ice to dam Paint creek and form in its basin a lake which, fed by the natural drainage and the floods from the melting ice would rapidly rise until it found a new outlet.

The Scioto having a deep pre-glacial channel, it is very probable that a lobe closed up the mouth of the creek at *B* some time before the main body of ice surmounted the hill and filled its bed. Between Slate Mills and the point *C* there was evidently a low depression formed by two ravines, one opening north into Paint valley, the

other south into Ralston's run (which then extended to the Scioto river, the creek having usurped its ancient channel) with a low divide between them. At its narrowest point this is now about 1000 feet wide. It is evident at a glance that Paint creek should have turned this way on abandoning its old channel; for this pass, as shown by its width, was much lower than any other that existed anywhere along the southern border. In fact, the stream must have gone through this way for a long time, and with a great volume of water, for it is impossible that so wide a valley could ever have been formed by natural erosion in so short a distance. Thus the whole drainage of Paint creek, reinforced by that from the glacier, would escape through this depression into Ralston's run at a level sufficiently above the Scioto to create a swift current, cutting both the depression and the run wider and perhaps deeper. When the glacier reached its ultimate extension, as a body, within the limits of Ross county, a spur reached entirely across the valley at the point *D* where the drift is piled to a height of about 120 feet above the present level of the creek. This was from a solid extension and not from a floating berg, because it is pushed up to this level over the solid rock. It would, consequently, shut off the former outlet and form from *D* southwestward a lake which rose until it began to flow over a col or saddle-back at the point *E* into a ravine, tributary to Ralston's run, which had worked its way back until it had to some extent lowered the crest in this range of hills; there was no corresponding ravine on the northern side. The cap rock is Waverly sandstone, full of joints; the underlying shale is so loose it can easily be dug out with a pick. When into such material a lake abundantly fed plunges from a height considerably greater than Niagara, the incoherent rock would disappear almost like wax before fire. If the present Ohio was closed at this time, the Scioto was a lake; if the former was open, the latter was a surcharged torrent.* In either case, it was backed up against these hills, forming a body of dead water in which all the rock eroded from the new gorge, along with such material as could be carried by ice, found a resting place, and settled on the drift that had been carried into the same backwater when the larger creek came down from Slate

*Since the above was put in type investigations in another direction have shown that the flood-height of the Scioto, immediately below Chillicothe, was at least 200 feet above its present bottom.

Mills. This we know, because an area of fully a square mile about *C* has a solid deposit of drift-material rising more than 100 feet above the creek, composed largely of sandstone blocks whose angles are scarcely worn, and masses of shale sometimes containing two or three cubic feet, which disintegrate after a few weeks of exposure to the weather. These could have come only from the gorge between *E* and the present mouth of Ralston's run. They are intermingled with sand and northern rock, promiscuously for the most part, but occasionally with a rude stratification as if the floods had been somewhat intermittent. The great apparent width of the valley below this point is due mainly to the filling-in by drift; but, it may be in part, also, to the earlier discharge of Paint creek having enlarged it to some degree, as mentioned above. The fall of ravines and minor streams outside the glaciated area is rapid; and in those filled with drift the depth to bed rock may be roughly estimated by carrying downward the line of slope of the hills on either side to their point of intersection. So of the larger streams. This statement, of course, does not hold good near the junction of two streams; when they have cut down to the level of those into which they flow, smaller streams can not further deepen their beds, but will swing from side to side thus making narrow bottoms. This is why there is always a widening of the valley where two branches unite; and in such cases the rule just given will not apply.

* * *

From the northwestern point of the hill southeast of Frankfort, one looks to the horizon northward over a practically level drift covered country. The hill on which he stands bears, on one hand north of east to the Scioto bottoms: on the other, it reaches a short distance southward, bends toward the west, and finally sweeps away northwest until it is lost to sight. This hill-land and the portion of the plain adjacent to it are drained by North Fork; the part north and east of Frankfort is drained by Deer creek. Both are of post-glacial date. Tbe latter, being entirely superficial as regards the drift, need not be considered: the former has a history.

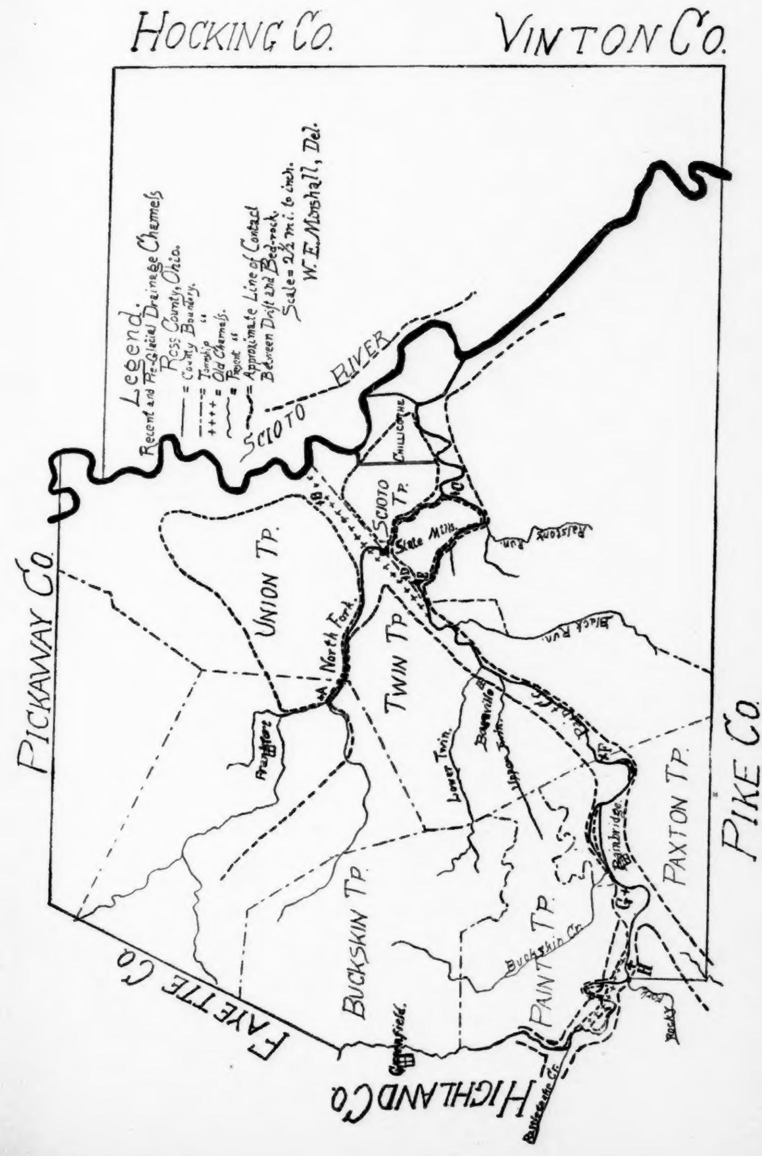
Prior to the advent of the ice, that part of the present valley of North Fork between Frankfort and Paint creek was a depression with an outlet in each direction, the dividing point between the two ravines being near where Union and Twin townships corner. At this point the shale hills are now less than 100 yards apart; just below (south)

they separate considerably, apparently planed out by the ice, and there are drift deposits more than 100 feet high through which the creek now cuts its way. These may have been formed by the advancing ice pushing through the valley a little ahead of that on either side which had to ascend the hills; or they may have been left on its retreat: or it is possible, though scarcely probable, they mark a re-entrant angle of the moraine. It is true there is a wide gap in the heavy deposits in the main stream below here, but it is more reasonable to suppose that they have been removed by erosion than to believe the ice-sheet would stop moving in a place so favorable to its progress. At any rate, a lake of considerable depth was at one time held back above them; for at the point *A*. on the hill-side, 75 feet above the railway, is a finely stratified deposit of sand. This, however, may have settled in the water which rose in front of the ravine (which then extended much farther to the north,) until it broke over the divide. When this happened, such water as went out this ravine became a part of Paint lake until the extension of the ice confined the latter above the point *D*. But between *B* and *D* there would still result from the melting ice a great quantity of water whose most natural, and indeed only means of escape until new channels were opened miles to the northward, would be toward *C* along the bed from which Paint creek had been so summarily shut off. This continued until the present course had been cut to a depth lower than the surface toward the east or west; and North Fork, being thus debarred from following the old valley in either direction, has ever since flowed directly across it, high above the original bed, as though carried on an aqueduct.

NOTE.—Too late to add to above paper, I discovered a glacial outlet in the eastern part of Ross county. A number of ravines from the hills back of Mount Logan and Rocky Knob, united and flowing past Mooresville or Halltown, discharged into the Scioto about four miles below Chillicothe. A smaller ravine skirted the northern slope of Rattlesnake Knob, and entered the river not far below the other.

With the greatest extent of the glacier, a lake was formed between its front and the hills a short distance west of Adelphi, over what is now known as Maple Swamp. This finally broke over into the first ravine mentioned, making a narrow gorge in the hills; at the

lower end of this there are drift-hills whose summits are at least 150 feet above Walnut Creek which now flows between them and the hills to the east. These deposits, extending for miles, and uniting with those made by the huge eddy formed by Mount Logan (which forced the glacial currents in the Scioto to the western hills), completely shut off these two pre-glacial ravines, and forced the water coming through the Maple Swamp gorge to skirt the hills, overflow the col back of Rattlesnake Knob, and sever that peak entirely from the range of which it formed a part. Through the narrow gorge thus made, Walnut Creek finds its way, and reaches the river miles below.


HOCKING CO.
VINTON CO.
PICKAWAY CO.
PIKE CO.
FAYETTE CO.
HIGHLAND CO.
Legend.
Recent and Pre-glacial Drainage Channels
Ross County, Ohio.
= County Boundary.
= Township "
++++ = Old Channels.
= Present "
= Approximate Line of Contact Between Drift and Bed-rock.
Scale = 2½ mi. to inch.
W. E. Marshall, Del.
SCIOTO RIVER
CHILLICOTHE
SCIOTO TP.
UNION TP.
TWIN TP.
BUCKSKIN TP.
PAINT TP.
PAXTON TP.
North Fork
Slate Mills
Black Run
Lower Twin
Bainbridge
Buckskin Cr.
Greenfield

PART III.

A Preglacial Tributary to Paint Creek and its Relation to the Beech Flats of Pike County, Ohio.

By W. G. Tight.

Reference is made in the preceding article, in this volume, on "The Pre-glacial and Recent Drainage Channels of Ross county, Ohio," on page 17, to the extension of the preglacial valley of the upper part of Paint creek to the southwest, at a point a little above Bainbridge. It was with a view to ascertain the course of this tributary to Paint creek that these studies were undertaken.

The results of glacial action along the margin of the ice sheet are so varied and at times so unexpected that almost every acre presents some new and interesting features. This region, lying as it does just on the boundary line of greatest glacial extention, is no exception. While it presents some characters common to some other localities studied, yet there are many new features which add especial interest to this field. A very casual observation revealed the fact that this preglacial channel extends to the Beech Flats of Pike county and is in some way connected with their origin. A view from one of the high Waverly hills at the junction of this valley with Paint creek would easily lead one to the conclusions stated by the author of the preceding article on page 18.

So striking are the topographical features of this region that we find them mentioned in the earliest writings on geology of this portion of the state. Dr. Edward Orton in his "Report on the Geology of Pike County" in the "Geological Survey of Ohio," Vol. II, 1874, makes the following statement with reference to this locality: "In the extreme northwestern . . . corner of the county, near Cynthiana . . ., there is a conspicuous example of surface erosion that does not belong to either of the systems thus far named, but which is

connected with the drainage systems of adjoining counties. The case is not explicable by existing agents of erosion. . . . The drift in the vicinty of Cynthiana often exceeds fifty feet in depth, and the origin of the great excavation which has here been effected must be sought in the glacial epoch, or in preglacial times."

Dr. G. Frederick Wright, in a number of articles published at various times, makes mention of the Beech Flats and the surrounding topography. In his recent work "The Ice Age of North America," 1891, on page 333, he gives a map showing the relation of the Flats and the head waters of Baker's Fork of Brush creek to the surrounding drainage systems, and makes some generalizations, based upon the Flats and certain features of Brush creek, which bear upon the important theory of the "Ice Dam at Cincinnati." While the value of this theory is not brought in question here, yet our conclusions, with reference to the origin of the Flats, lead to the belief that this theory must rest on other proof than that furnished by this region.

It has been my privilege to visit this region on a number of occasions, and personal examination has been made of almost the entire area represented on the map, Plate II. This map is constructed from data obtained from the following: "Map of the Marietta and Cincinnati Railroad, prepared by M'Gee and Phillips, Geological Locations and Sections by Prof. E. B. Andrews"; "Highland County, Ohio," from "Ohio Geological Survey"; Report of 1870; "Map of Highland, Ross, and Pike Counties"; of the "Ohio Geological Survey" Vol. II; "Pike and Road Map of Adams, Brown, Butler, Clarke, Clermont, Clinton, Darke, Fayette, Franklin, Green, Hamilton, Highlands, Madison, Miami, Pickaway, Pike, Preble, Ross, Scioto, and Warren Counties", "Geological Map of Ohio by Edward Orton" to accompany Vol. VI, "Ohio Geological Survey"; "Geological Map of Ohio by Edward Orton" to accompany Vol. VII, 1894, of the "Ohio Geological Survey"; with others. The topographical characters indicated on the map have been as accurately located as possible by sketch maps and field notes. They were located on the sketch maps in the field work, in relation to the pikes and roads, but it was not thought best to enter such details on this map as were not essential to the explanation of the work.

In order to get the facts presented in a connected manner, the reader is invited to accompany the author on an ideal trip of investigation, which is, however, with but one or two slight deviations, al-

most the exact duplicate of one of the trips taken during the study of the region. The line of this proposed trip is indicated on the map. (Plate II.)

Starting from Bainbridge, Ross county, our first point of observation will be the high quarry hill A just south of the town. This hill capped with Waverly freestone rises 450 feet above Paint creek, to an elevation 1180 feet A.T. A view to the north across the valley of Paint shows the hills forming the north wall of Paint valley over a mile away and rising nearly to a level with the observer. To the east extends the very deep and broad valley of Paint on its way to the Scioto. Large drift deposits fill the valley along its northern side, often rising to 150-200 feet above the creek. There are numerous terraces in the valley, and the creek is undoubtedly 150 feet above the rock floor of the valley. Westward the valley is distinguishable as a very evident trough of preglacial origin as far as the junction of Paint and Rocky Fork. Beyond rises very rapidly the drift-buried tableland of northern Highland county; and the well defined preglacial valley of Paint seems to end, suggesting some interesting problems in that direction, for somewhere in that locality we must look for the preglacial channel of reversed Brush creek.

As the view to the south is cut off by timber, we return to the pike and pass westward about one mile, where the view to the south shows a break in the high Waverly capped hills, and their place is taken by others of somewhat less altitude. From the pike along the creek the change in altitude would hardly be noticed; but as these hills are destitute of timber, they offer a prospect of an extended view to the south, and with this hope the ascent of the highest is undertaken. On reaching the summit at B, 190 feet above the river, and 990 feet A. T., it is found that this hill only concealed from the view on the pike still others just beyond, which rise just enough higher to obstruct the coveted view southward.

Our surprise is great, when almost on the summit of the next hill we find a ground-hog burrow, and the material revealed indicates glacial drift. The first thought is that this can not be drift at an elevation of 200 feet above the creek, and on the south side of Paint valley. A glance southward shows a comparatively level plain and not a rolling hill country as might have been expected.

This then is the extreme northern edge of the Beech Flats. What had concealed the real nature of these drift hills was their steep

slopes and sharp summits. It seems almost inconceivable that these till deposits could have retained such steep gradients for such a length of time, yet it is quite evident that the high angles are the original slopes of the moraine and are not due to the subsequent erosion. There are many deep gullies and ravines cut by present agencies which reveal the true till structure of the deposits, but these can be readily distinguished from the older forms, although in both cases the slopes are so great that it is almost impossible to climb them. The surface is sparsely strewn with erratics. One of fine grained trap was estimated to weigh a hundred tons. There was also found a jasper conglomerate about the size of a man's head. Many observations in the immediate vicinity of B gave a mean elevation of 200 feet above Paint creek, 1000 feet A. T. The maximum elevation recorded was 250 feet above Paint, 1050 feet A. T.

The most conspicuous object in view from B is a high treeless hill to the west, which is located on the Giffen farm and which I have called Peach Orchard hill. The eastern exposure of the hill is very steep, and is much cut up by gullies which show very beautifully the contact line between the drift and the rock soil. The thin covering of boulder clay is pushed up the side of the hill at least 70 feet above the mean level of the Flats.

From the top of the hill, C, the prospect is grand and is well worth the climb. At an elevation of 485 feet above the creek, 1285 A. T., with an unobstructed view in every direction, it can not but enthuse the observer. The topography is spread out for inspection like a huge relief map, which it really is. Northward the view is similar to that from A as is also the view to eastward,—with this difference, station A is over two miles away with a broad and deep valley intervening. Following with the eye the outlines of this valley, as indicated by the long lines of hills, it is seen to extend many miles to the south, and within its rock-bound walls 250 feet below lies a tract of country, the Beech Flats, which never seem so flat as when viewed from this elevation. To the west extends the long ridge of sandstone hills which form the south wall of Paint valley. Just south of this is another ridge running nearly parallel with it with quite a wide valley between. As it is not possible to determine all the characters of this valley and its westward extension, we descend into it and proceed westward along the dirt road which runs along its northern side.

At D a spur extends southward from the Paint creek ridge, and the valley is much narrower here. It again widens to the westward. The small stream which drains it flows along the southern side and reveals the rock for much of the way to Rocky Fork at Barrett's Mills. At this point the valley seems to end, with the western ends of the two parallel ridges standing out in bold relief, with no visible counterparts on the westward side of Rocky Fork, which has here cut its way through the drift and developed its deep and picturesque gorge in the limestone.

From Barrett's Mills the journey leads along the range of hills bordering Rocky Fork. This ridge is crossed with the expectation of gaining Brush creek valley.

At E a small stream is crossed which is flowing westward instead of southward. It is at once recognized as not being Brush creek, and so is examined more closely and is found to flow into Rocky Fork between two high sandstone hills and in a rock gorge with vertical walls. This gorge is 75—100 feet wide and is clearly seen to be deeply filled with drift. It is very apparent that the gorge is not the work of the present stream, but that the latter is running, at least at the upper end of the gorge, much above the rock at an elevation of 940 feet A. T.

The next objective point is F, a very high cleared hill south of the village of Carmel. This hill reaches an elevation of 360 feet above Carmel, which is given as 939 feet A. T. From F the view is as grand and extensive as from Peach Orchard hill at C. The points most interesting in this study are the broad valley extending to the northeast to Cynthiana and filled with an arm of the Flats, and another broad valley very similar to the last, but stretching off to the southeast. The view to the northeast reaches to the horizon along a continuous valley. The view along the valley to the southeast is terminated in five or six miles by a line of hills, which are later found to be the hills forming the eastern wall of the Brush creek valley.

After observing a few land marks that will aid the recognition of our point of view, we descend into the valley again and traverse its rolling surface to Cynthiana. Here the drift shows a mean elevation of 200 feet above Paint creek, 1000 feet, A. T. Ascending a hill, G, just south of the village, our landmark at C is easily located, and it at once becomes evident that the axis of the valley, observed from C, passes east of Cynthiana and farther to the southwest.

Following along this valley, with its drift surface much cut up into hills and valleys (yet when on top of the hills this surface appears quite even) we reach a point H, near a large iron bridge across Brush creek, on the pike from Sinking Springs to Carmel. Here is observed a side valley entering from the northwest. Crossing the bridge and proceeding along the pike to a high hill of till at I, 191 feet above Paint creek, 85 feet above the water in Brush creek at the bridge, the landmarks at F are visible, and then is understood the reason why this valley when viewed from F, appeared to be closed at its southeastern end.

As we pass down the valley of Brush creek, it is noticed that while the creek is running in a large valley in the drift-filling it is nevertheless flowing with a very sluggish current. The high sandstone and slate hills are closer together and the rock valley is much narrowed. One looks in vain for a gap in the hills which will indicate the position of the exit of the creek. The only apparent opening is in the direction from which we have come.

We proceed to K along the bed of the creek which now* contains no water, except in the deep holes and is a muddy and sandy channel. Here is a small stream entering from the western continuation of the old valley. Here also are found evidences of a buried rock ravine which occupies a position more central to the main part of the old valley. This old ravine is filled with till and its walls but thinly covered. Its position is shown by a meander of the channel of Brush creek and also by a side ravine of recent erosion, which crosses it. The small tributary to Brush creek is fed by a number of springs and flows along the contact line of the drift and rock, along the southern side of the old valley, its former ravine near the center of the valley being filled with the drift.

Standing at the mouth of this small stream, not 500 yards from the place where the channel of Brush creek is transformed into a narrow and deep gorge, one unfamiliar with the facts would find no marks to indicate the location of the exit of Brush creek from this apparent basin, so skillfully has nature concealed the facts by topographical features, and a luxuriant growth of underbrush along the stream, gradually merging into the forest of the mountains sides.

Shults' mountain, L, presents the most favorable opportunity for a comprehensive view. From its summit, 440 feet above the waters

*August, 1895; an extremely dry season.

of Brush creek and 1325 feet A. T., the broad plain of the Beech Flats stretches away to the northeast and the horizon is formed by the hills forming the north wall of Paint creek, opposite Bainbridge. To the north at the foot of the mountain, lies the short westward extension of this valley beyond the exit of Brush creek. In the distance are visible the tops of the numerous ridges shown on the map. The appearance being that of a very hilly country and also resembling the view to the east and southeast. So similar are these two views, that the conclusion is inevitable, that their topographical features are the results of similarly operating forces. The region to the east and southeast is beyond the limits of the ice and the natural inference is, that the region to the north has been so slightly modified, that the main features of its preglacial forms are preserved.

Fisher's mountain M stands out farther to the southwest, and its summit is reached at an elevation of 410 feet above Brush creek, 1295 A. T. To the south lies a broad expanse of low lying country in the vicinity of Sinking Springs. From this low region the general slope of the country rises rapidly across Adams county to and beyond the Ohio river. Into this inclined plain Brush creek has excavated a narrow and deep gorge. So narrow are the gorges of all the streams in this district that from the point of view chosen it is impossible to determine their courses. From this same depressed region the country level rapidly rises to the west to the water shed separating the waters of Brush creek and Rocky Fork from those of western Highland county. This region is sparsely covered with drift. The land also rises rapidly to the northwest to the table land and drift-covered region of northern Highland county.

The descent is now made in order to study the characters of the Brush creek gorge which lies, as shown from our maps, between Fisher's mountain and Fort Hill, but which was not visible from the summit of the mountain. After a very steep descent of 410 feet, the rough mountain road passes between two walls of limestone, evidently a great fissure, and emerges in the dry bed of Brush creek gorge. The slopes of Shults' and Fisher's mountains and Fort Hill have angles of about 35 degrees and where these plains of the mountain sides would intersect occurs the U shaped gorge of the creek, with vertical walls of about 50 feet and the gorge about 100-200 feet wide. The bed of the creek is composed largely of limestone gravel with a small percentage of northern drift pebbles. In no part of the gorge examined in this

cut between the mountains was bed rock shown in the channel. The conclusion is inevitable that the considerable volume of water in the creek above the gorge must find its way out through the gravel filling in the bed of the gorge. The gorge of this fork of Brush creek was examined at many points to the southward and everywhere was found a small percentage of northern pebbles. This would be expected as the head waters are in the great till deposits of Beech Flats.

An examination of the data obtained reveals the following relations. The Beech Flats is a large tract of level land lying at an elevation of 1000 feet A. T, and 200 feet above Paint creek, occupying a portion of the southwest corner of Ross county, a portion of the northwest corner of Pike county and a portion of the eastern edge of Highland county. This land consists of a great deposit of till, showing but a few slight marks of stratification, being in fact largely typical boulder clay. It is bounded on all sides, except at its northern edge, with high rock hills, capped with Waverly freestone which reach an average elevation of 1200 feet A. T. At its northern edge, where it borders the valley of Paint creek, is exhibited an average of 200 feet in the thickness of the deposit. This thickness decreases towards the south and southwest, due to a rise in the rock floor, while the top of the deposit remains at nearly the same level. The elevation of this surface is the same as that of the drift deposits on the north side of Paint valley and also of those to the west in the vicinity of Barrett's Mills and Carmel, both of which are beyond the ranges of hills enclosing the Flats. The surface of the Flats is much cut up into drainage channels, so that the roads and pikes which traverse it in every direction are by no means level, but on the other hand are quite hilly. These channels in many cases seem to be out of proportion to the streams that occupy them. The two principal ones being, the small stream that rises near Cynthiana and flows west into Rocky Fork, the other and larger being Baker's Fork of Brush creek, which also rises near Cynthiana and flows south past Fort Hill and Shults' mountain. In both cases the valleys these streams occupy in the drift seem too large to be easily accounted for by present forces, especially in view of the slight amount of change observed in the forms of the deposits next to Paint valley. Both these streams pass out of the district through rock gorges. The former at an elevation of 940 feet A. T. and the latter 885 feet A. T. In both cases also the gorges are now partially filled and the streams are not flowing through the gorges on rock floors. The former

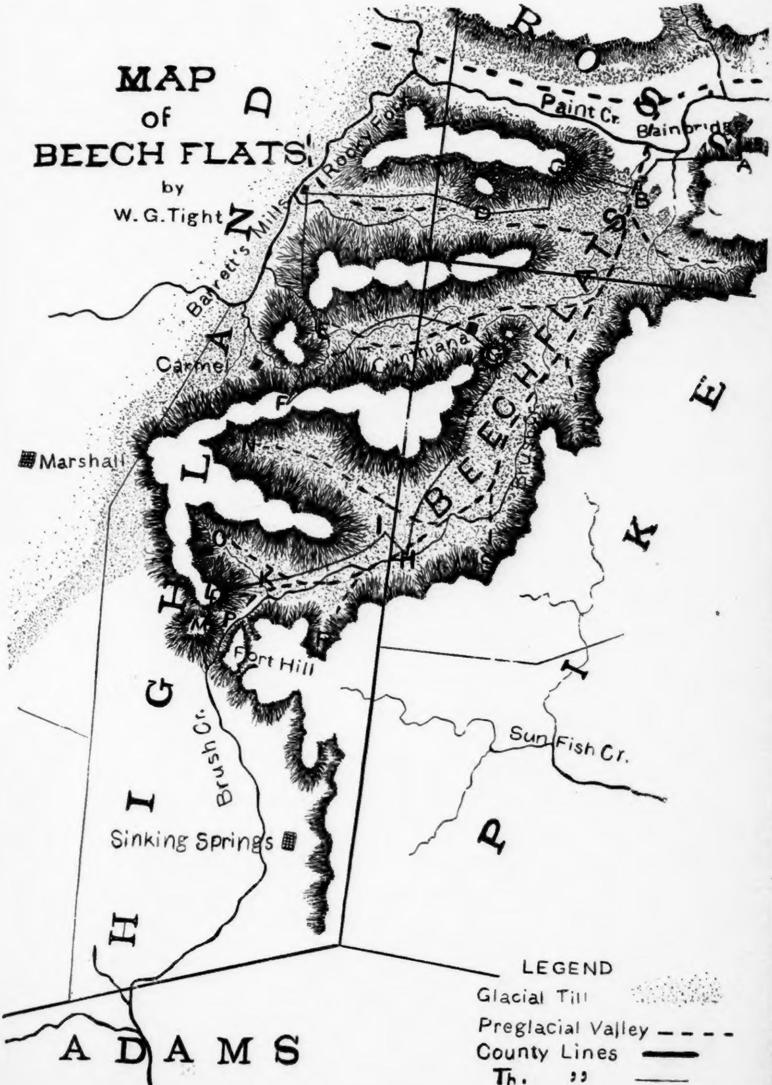
stream has a fall of about 75 feet in its source to its gorge, the latter, Brush creek, has a fall of about 121 feet from Cynthiana to its gorge. The gorge of the former at E is 140 feet above the base of the drift at Paint creek, and the gorge of Brush Creek is 85 feet above the base of the drift at Paint creek. If it were possible to remove the drift from these valleys it is evident that these streams would be reversed. The fact is more striking when it is remembered that the bottom of the drift at Paint creek is 150-200 feet above the preglacial bed of Paint valley.

The conclusions which are drawn from the above facts are, that prior to the advent of the ice, the present location of Beech Flats was represented by a valley with numerous smaller tributary valleys, all tributary to the valley of Paint Creek. The heads of these valleys were at D, E, N, O, P, R, T, and V. At all of these points were cols connecting with adjacent drainage basins. As the ice advanced southward, planing and filling, it made the great drift plain of northern Ross and Highland counties and of Pickaway, Fayette, Franklin and Madison and other counties to the northward as its comparatively level ground moraine. It reached across the preglacial valley of Paint creek west of Bainbridge and pushed a great tongue of ice into Beech Flats valley. As this tongue advanced into this valley it divided again and again sending fingers along the tributary valleys clear to their head waters. Under these ice fingers was deposited the drift of the Beech Flats as a ground moraine. The spur which first separated from the main stream of ice crossed the col at D and probably joined the main mass of the ice sheet beyond Barrett's Mills. The next spur passes up the valley west of Cynthiana. The next spur passed up the next tributary valley to M. The main axis of movement continued beyond K to O, as shown by the till and boulders beyond the exit of Brush creek.

Large volumes of water were formed from the melting of these ice masses, for however much of rigor is attributed to the climate of the glacial period to account for the ice age, yet it seems evident that the margin of the ice extended beyond the line of perpetual snow and mean annual temperature of 32° F. into a temperate climate. The limit of the extent of the ice was determined by its rate of marginal melting as opposed to its rate of flow and supply of material by precipitation. The waters formed in the Beech Flats valleys found two outlets. One taking the water from the ice mass in the valley west of Cynthiana developed the gorge by cutting down the col at E. The main

volume of the water flowed over the col at P and developed the Brush creek gorge. As climatic conditions prevailed and the ice began to recede from the heads of these valleys the volume of water which filled the outlet streams at E and P remained large and excavated large valleys in the ground moraine thus exposed and cut deep and wide gorges in the rocks at E. and P. As soon however as recession had proceeded as far as Paint creek this new channel was taken by the glacial waters and the water in Brush creek was suddenly reduced from a considerable torrent to a small stream fed only by meteoric waters. As the volume of the water was reduced suddenly there was no opportunity for the development of terraces in Baker's Fork of Brush creek. Subsequent erosion has resulted in the partial filling of these gorges and the present state of movement is now uncertain.

If the above conclusions are warranted the Beech Flats must then be considered as a portion of the great level topped ground moraine so extensive within the limits of the ice movement in the portions of the State to the north and west of the Flats.


MAP
of
BEECH FLATS
by
W. G. Tight
ROSS
HIGHLAND
PIKE
ADAMS
BEECH FLATS
Paint Cr.
Bainbridge
Rocky Fork
Barrett's Mills
Carmel
Cynthiana
Marshall
Fort Hill
Brush Cr.
Sun Fish Cr.
Sinking Springs
LEGEND
Glacial Till
Preglacial Valley
County Lines
Tp. "

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8
9
5